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# An integrated approach for an academic advising system in adaptive credit-based learning environment

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**Abstract.** Nowadays, with the growing importance of the credit-based learning in current educational environment, strong academic advising system is an essential ingredient of learner success, supporting personalized advices aimed at effective and efficient learning. In that context, within the scope of this paper, an intelligent academic advising system approach is introduced focusing on integrating technology-enhanced learning methodologies into a pedagogy-driven and service-oriented architecture based on semantic technology. Specifically, a knowledge-based framework is conceptually introduced, assisting learners in identifying and assessing academic alternatives for their life goals as well as making meaningful educational plans that are effectively compatible with those goals. In the proposed framework, the learning data warehouse plays a key part with information about learners' behavior and navigation so that intelligent algorithms can be applied and patterns can be obtained as the basis for course advising. Moreover, a data integration prototype is studied and developed as a resource discovery tool to map, convert and harvest advising related information from structured and semi-structured learning repositories. Thus, the described framework emphasizes its application within an open adaptive credit-based learning, providing abilities for accessing and managing, in an integrated manner, the adaptive interaction, adaptive course delivery as well as adaptive content discovery and assembly.
*Keywords:* Credit-based learning, Academic Advising System, Knowledge-based framework, Data integration

## 1. Introduction

Like in others developing countries, in Vietnam, the pedagogical mission and governance structures of universities face credible challenges from an exponential growth in learner enrollment and a widely shared recognition that higher education is the foundation of a knowledge society essential to Vietnam's future [1]. One potential solution often proposed to address this concern is further implementation of the credit-based learning system, which has been increasingly recognized as a ubiquitous mode of instruction and interaction in the academic as well as dynamically changing world [2]. On the basis of credit accumulation, Web-based learning systems are no longer closed learning

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environments where courses and learning materials are fixed and the only dynamic aspect is the organization of the material that can be adapted to allow a relatively individualized learning environment [3].

However, with the increase popularity of online education, e-Learning systems have to face critical challenges, such as the learners' feeling of isolation and disorientation in the course hyperspace as well as the difficulty in addressing the needs of each individual learner. To help promote learner mobility, learners have to be supported in finding information, in decision-making, in dealing with all the formalities when filling in the application forms [4].

In this context, Web academic advising system for learners is gaining popularity in recent times among Universities. The major goal of academic advising is to help learners to develop educational plans that are compatible with the personal life goals. The importance of advising lies in assisting the learner in identification of personal initial, life goals and frequently changes of direction. On the more applied level, academic advising assists learners in understanding the regulations and requirements of a chosen program, and selecting the most effective and efficient path toward graduation [5].

Usually, Academic advising is an important and time-consuming task and different tools/techniques can be used to make it an efficient process [5]. Most of the process, however, relies on personal interactions between learners and counselors, which lead to problems such as poor utilization of resources. Meanwhile, Learning Management Systems (LMS) keep a vast amount of data collected through the tracking of the learners' interactions, such as time spent on course pages, scores achieved in quizzes, postings to discussion forums, etc. [6]. However, this tracking data is rarely used by LMS to automatically guide or advise the learners in their course selection and scheduling.

In response to these problems, the main contribution of this paper is to conceptually introduce an integrated knowledge-based framework based on service-oriented architecture along with semantic technology, implemented in the context of Hue University. In the proposed framework, the learning data warehouse plays a key part in collecting vast amounts of learner profile data, i.e. learners' behavior and navigation. On the basis of this, data mining and knowledge discovery techniques can be applied to obtain interesting relationships between attributes of learners, assessments, and the solution strategies adopted by learners. Moreover, a data integration prototype is studied and developed as a resource discovery tool to map, convert and harvest advising related information from structured and semi-structured learning repositories to the data warehouse. Taken together and used within the online educational setting, the value of the proposed approach lies in semi-automatic assisting learners to identify and assess academic alternatives for their life goals as well as making meaningful educational plans, improving learner performance and the effective design of the online courses.

The rest of this writing is organized as follows: section 2 introduces some approaches related to our work; section 3 presents the Hue University context, one of the biggest universities for training, research, as well as cultural, scientific and educational exchanges in Central Vietnam; section 4 proposed framework with its detailed specification and explanation of core modules, hereafter, courseware structure and metadata required to describe the course material is then presented; and in section 4, a

prototype of data integration based on Web service is described. At last, section 5 gives a summary of what have been achieved and future works.

## 2. Related works

Since the introduction of management information systems into university settings to deal with and manage massive amounts of information, attempts have been made to use computers as advising tools. In this section, we will review relevant work in the computer-based advising in educational systems to identify important issues that should be considered in building a framework for advising the learners in credit-based e-Learning system.

As stated in previous section, Web academic advising system for learners is gaining popularity in recent times among Universities, such as Indiana University, North Carolina State University, West Washington University, etc. [7] However, it seems that the most of the international related work has been done concerning about the career guidance rather than focusing primarily to study guidance, when universities, in the beginning of the 21st century, "have seen a rapid growth in guidance services", but that "there is no common trend" among these services [7].

Most of the pages entitled Web-based advising are typically a bulletin board with advising-related announcements; a repository of official documents in PDF or HTML format; a collection of useful links that help learners get official advising-related information off the Web; or a combination of those [4]. They hardly include any scripts or Web server programs to process specific learner information and produce customized advice for learners [4]. Over the years, there are approaches in developing an electronic academic counseling system primarily focusing on educational planning and advising resources in support of learner's academic objectives. E.g. Marques et al [5] introduced a system that was intended to make learners more proactive in advising-related issues, integrating conventional advisor advising and Web-based advising to form a learner-centric advising model to engage undergraduate learners actively in their education process.

With enormous repositories of learning data on the Web, there arises a potential trends of applying knowledge discovery techniques in web-based academic advising system, in which Data mining techniques could be applied to web-based distance learning in order to track learner activities in a course web site to extract patterns and behavior profiles that help learners to improve their learning results [8, 9]. Meanwhile, based on data extracted from log data in an education web-based system, Minaei-Bidgoli and Punch [8, 10] use data related to educational resources (e.g. web pages, demonstrations, simulations, homework assignments, quizzes) and user information, data mining methods are analyzed for extracting knowledge to identify types of learners.

Nonetheless, just knowing most frequent patterns is not enough: it is of vital importance to integrate this information into the system so that this information is used proactively when a learner is connected. An evolving e-learning system is described in [7] which can adapt itself to its users and to the open web based on the usage of its learning materials. The system users are clustered based on their learning interests. Moreover, based on ontology and agent technology, e-Advisor, an Intelligent System that Facilitates Academic Advising and Program Planning, is designed to help assist learners in choosing their courses in a distance-education based university setting.

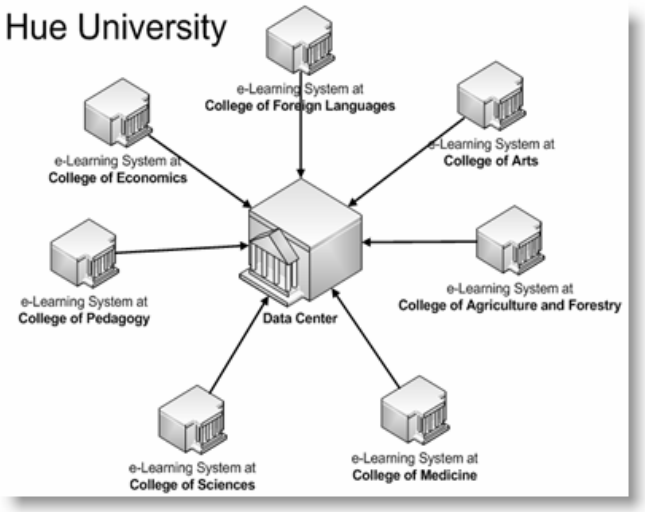
However, the existing approaches only develop web-based academic advising system with the advising logic is tightly coupled to the system itself and without intelligence help. Meanwhile, Academic advising and program planning is a complex problem solving process that involves intensive multi-participant cooperation in an uncertain environment [11]. Therefore, effective computer-aided program planning and advising hinges on the modeling and representation of knowledge about the domain knowledge, program structure and regulations as well as learners. In our work, we present a semantic-based academic advising framework with a data warehouse architecture is one of the core components, taking advantage of tracking data supporting automatically guide or advise learners, reducing their workload and empower their learning. Moreover, information related to courses, topics, and activities will be integrated with navigation information prior to the application of data mining algorithms in order to obtain patterns. In this context, we focused on semantic heterogeneity problems in data integration, especially in the extraction, transformation and loading (ETL) process [12], which is one of the main objectives of this paper.

## 3. Hue university context

Hue University is composed of 7 affiliated colleges and variety of center such as Learning Resource Center, Center for Distance Training, and Center for Information Technology, located in various areas of the city and incorporated in 90s to address the problems associated with better managing and using the massive amounts of information required in the growing areas of higher education. All 7 of the colleges are general-purpose institutes of higher learning offering baccalaureate and graduate degrees in the Natural Sciences, Social Sciences and Humanities, Medicine, Agriculture & Forestry, Economics, Fine Art, Foreign Languages as well as other selected degrees.

As a step towards lifelong learning, Hue University Information Technology Center has developed the e-Learning Portal, making learners more self-directed and responsible for their own learning path, by means of advanced learning technology to structure and organize their lifelong learning process. Since June 2007, this e-Learning Portal has been widely adopted in member colleges of Hue University, offering the opportunities to enhance the learning environment of our learners as well as the management and administration of programs and module delivery and support.

In august 2008, Hue University will begin the first semester adopting the credit-based degree system defined in the credit-based learning strategy of Ministry of Education, the main goal of which is to improve the competitiveness and attraction of Vietnamese higher education. For higher education in the Hue University, the major goal of credit-based learning environment is to provide a distinguished University System which will support maximum educational opportunities for the learners, without unnecessary duplication or proliferation, through distinguished member colleges that have separately designated responsibilities and which will collectively offer programs in all disciplines and professions at all levels [6].




The new context on University degree emphasizes that the universities should pay extra attention to the quality assurance. Many standards and guidelines for quality assurance in the Higher Education area have been defined within higher education Universities. One subcategory in that area is the learning resources and learner support which are defined that universities should ensure the resources available for the support of learner learning are adequate and appropriate for each offered program; again bring attention to the need to enhance the quality of academic advising and to improve the management of the curriculum.

In practice, it has been stated that every learner will create or be created a personal study plan for his studies in the beginning of his academic career. The university provides the requirements of the Bachelor or Master degree which must be fulfilled by the learner in effort to be graduated. On the other hand, the university offers set of courses in every period. In this context, the counseling must include instructing the learner on how to best benefit from the given tool and counseling itself [11]. The personal study plan helps learner to schedule studies for his forthcoming year and it also stands as a tool for monitoring the progress of studies both for the learner and the universities.

By sharing a commonality in program offerings and common course numbering in these areas, the transferability of coursework among Hue Colleges can better meets the emergent needs for the single, system-wide advisement system. A common prefix and course number assigned to similar courses within the University allows for articulation across colleges in the advising system without the need for manual input to the Learner Academic Advising System.

## 4. Knowledge-based academic advising system framework in adaptive credit-based learning environment

This section proposes a framework based on semantic technology and describes its main mechanisms, allowing users to generate semi-automatic computer-based advising in e-Learning systems using Decision Support techniques such as Data warehouse and Data mining. The system is currently in development and includes the essential functionality required of an academic advising system. In particular, the proposed framework capable of integrating learner information, including academic

program and course history, and making a reasonable recommendation of courses learners could enroll.

The key feature of our approach in developing tracking data is to use terminology concepts as both a medium of domain knowledge representation and a navigable structure, establishing the semantic foundation for the framework. Moreover, in order to be interoperable, these information resources must comply with technological standardization, in addition to knowledge standardization (consensus on the meaning of educational content) [13]. In our framework, integrated information resources are represented using standard formalisms, including standards, such as Dublin Core as well as XML and its corresponding recommendations. Knowledge-based Academic advising system architecture with core components is represented in the Figure 1.

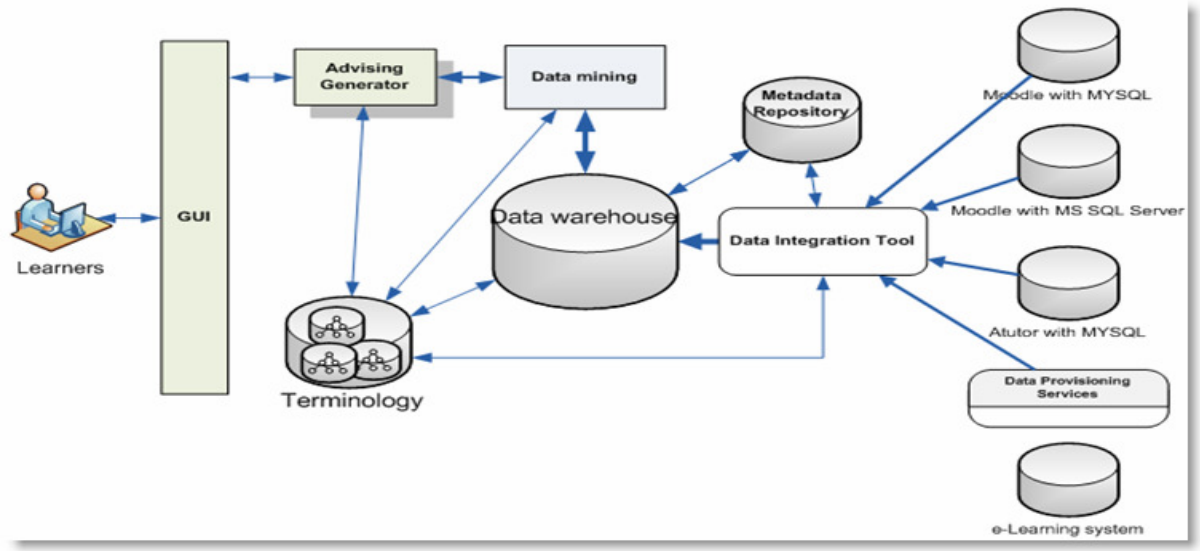



Fig. 1. Academic Advising Framework and its main components.

With learning offers from universities or colleges, which are highly structured, leading to a specific accreditation and have domain experts that guarantee quality like in universities, terminology or metadata recommendation techniques will be the most suitable. Curriculum offered by an educational institution is essentially a catalogue containing all courses offered along with their descriptions. Each course is described by a set of attributes, such as the period of the year (term) it is offered in, the set of courses it is a prerequisite for, the set of atomic skills it leads to, etc. This ***domain knowledge*** provides controlled learning vocabularies with certain metadata elements, e.g. subject and keywords: content description can be visible in the terms such as "Learning object", "Module", "Lesson", etc. Other concepts like "Introduction", "Explanation" and "Example" are used to describe contexts for the learning content. The most important part of the structure model is terms describe relations between learning content such as "has_Component", "partofLesson", etc. All this metadata could be used to recommend courses to learners.

The conceptual model is specified in OWL resembling an simple ontology specification, i.e. defines classes, individuals, and properties, and uses OWL properties to define relationships. It makes links to resources defined in the domain knowledge. The proposed framework uses

Protégé OWL extensively for input and output of OWL ontologies and models, creating and changing OWL resources and resolving domain ontology queries. We also use the generic reasoner from Protégé to make inferences from the domain ontology.

Using Protégé OWL, the domain knowledge described above is represented through classes as well as properties, constraints and rules on identified classes. With the ability of loading and saving OWL files in various formats, the framework can take advantage of the declarative formal representations of well-defined semantic background by means of ***metadata repository***.

The more business related information we gather the more profit we can make out of it, and consequently, the most intelligent recommendation will be made [9]. In this approach, the proposed framework is based on a comprehensive web data warehouse integrating information that have to be stored, e.g. *Information gathered by the operational systems of interest for users profiling*: information related to students (requirements, preferences, and behaviors), enrollment, exams and qualifications; *Navigational information*: all the information related to users navigations gathered by web server: (sessions, time of stay in courses ...). During an extensive ETL (extract, transform, and load) process [14] according to the data semantics, the specified data is added to the warehouse from distributed data sources.

In this context, one of the most important components in the framework is the ***data integration tool*** proposed to handle the design, integration, and maintenance of heterogeneous schemas of learning information resources, including tracking data of learners, courses, etc. It serves for describing each local schema and the mapping rules between a local schema and the global schema. In this component, the well-defined terminology will provide a systematic and semantic way to map different terms to find the specific information interested.

By the means of the data integration tool, our approach is also aimed to provide abilities for interoperability searching and metadata integration among learning information resources, provides rich information about learners and can be used to automatically generate build learner models. These models should hold knowledge required to generate appropriate advice to learners. The most important role of this component is to integrate data from different data sources with two methods to connect to data source: connect to data source via Web Service and connect directly to data source. The result of the integration process is saved in the form of XML-based file with Dublin core standard.

For largely autonomous organizations such as e-Learning, the amount of data is so great that manual analysis of the data in timely manner is difficult, if not impossible. The need to handle such large volumes of data led to the demand that data repository must be readily available and easily accessible. In our approach, the integrated data will then be loaded into a ***data warehouse*** with twofold structure: on the one hand, it has to store information so that data mining algorithms can be applied and patterns are obtained [9]; on the other hand, such an structure has to be the repository of patterns applied to data so it stores information about learners' behaviors and navigation patterns. This data warehouse, supporting the consolidation of atomic level data from multiple data sources in a structured way and enabling timely, accurate recommendation.

Given the multidimensional structure of defined data warehouse, the knowledge-based framework supports the off-line module (mining tool) and the on-line module (advising engine). The proposed framework can also

support frequent item sets, depicting the knowledge that obtained from navigational activity of other users who act commonly with the current user. Using the knowledge of the domain, the ***Advice Generator*** can compute the potential recommendation set, i.e. retrieve a list of the most relevant courses found in the domain terminology for the given inquiry. Specifically, the Advice Generator will investigate and analyze the constructed learner models and generate appropriate advice to learners.

On the basis of learner patterns discovered from the data warehouse and taking advantage of the domain knowledge, the proposed approach focuses only on those sets that come from the combination of the domain knowledge's recommendations and the current user. Thus, the framework can reduce the time spend on parsing all frequent item sets and association rules, resulting in a smaller searching space.

Hereafter, the system will rank the courses according to the perceived relevance to the learner. This initial list represents the proposed recommendation. Then the Advice Generator can acts as a filter for the proposed solution by removing any course that the learner is not able to enroll in the next semester, in the circumstance that courses for which the learner does not satisfy the prerequisites. Also based on the domain knowledge, the filter next removes courses that are not relevant to satisfying the learner's academic program requirements. For example, if either of two essentially identical courses satisfies a requirement and the learner has already completed one, the filter removes the other course from the proposed solution. Finally, the filter will use characteristics provided by the learner to present a ranking of course recommendations. With the list of highest ranked recommendations, the learner may filter the list manually, removing courses that are not appropriate.

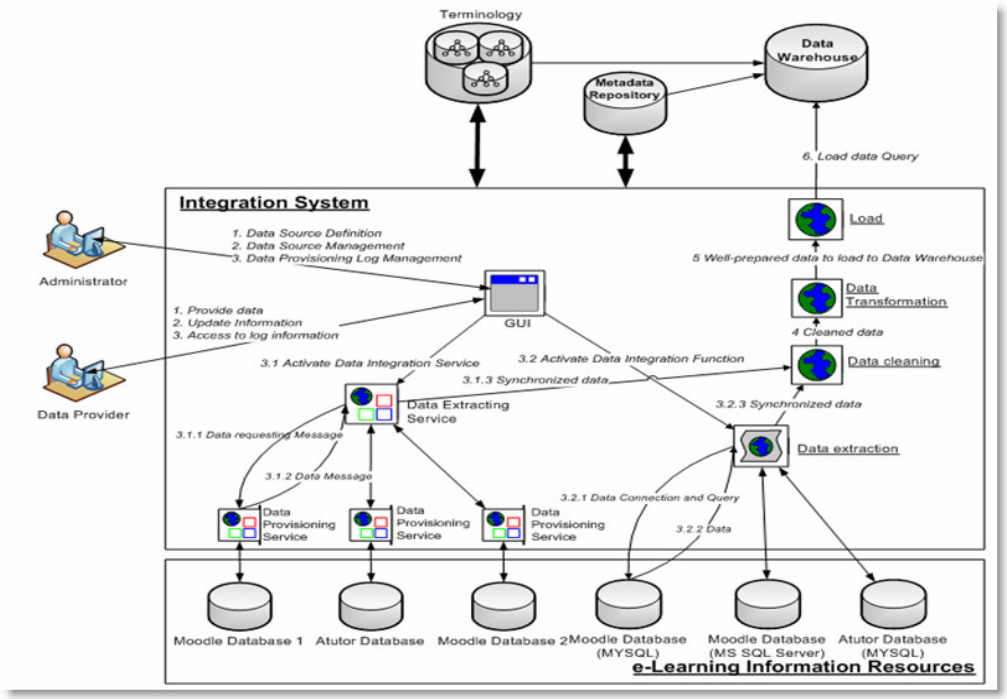



Fig. 2. Business model of the Data integration Module.

Moreover, based on dimensional hierarchies, the system can support OLAP-like aggregation capabilities, thus provides more complex recommendations that deal not only with individual criteria, but also with groups of criteria. For example, we may want to know not only how individual users like individual courses but also how they may like categories of courses.

Since the learning history data sources are of interest in the architecture, one of the very first modules that we have implemented is the data integration tool, establishing the correct relationships between the local schema and the data warehouse. In that context, in the process of integration, the Data Integration tool allow data provider to save the maps of data source. Based on mapping information in XML-based files, the data from various sources can be re-classified and re-interpreted as well as integrated using terminology concepts.

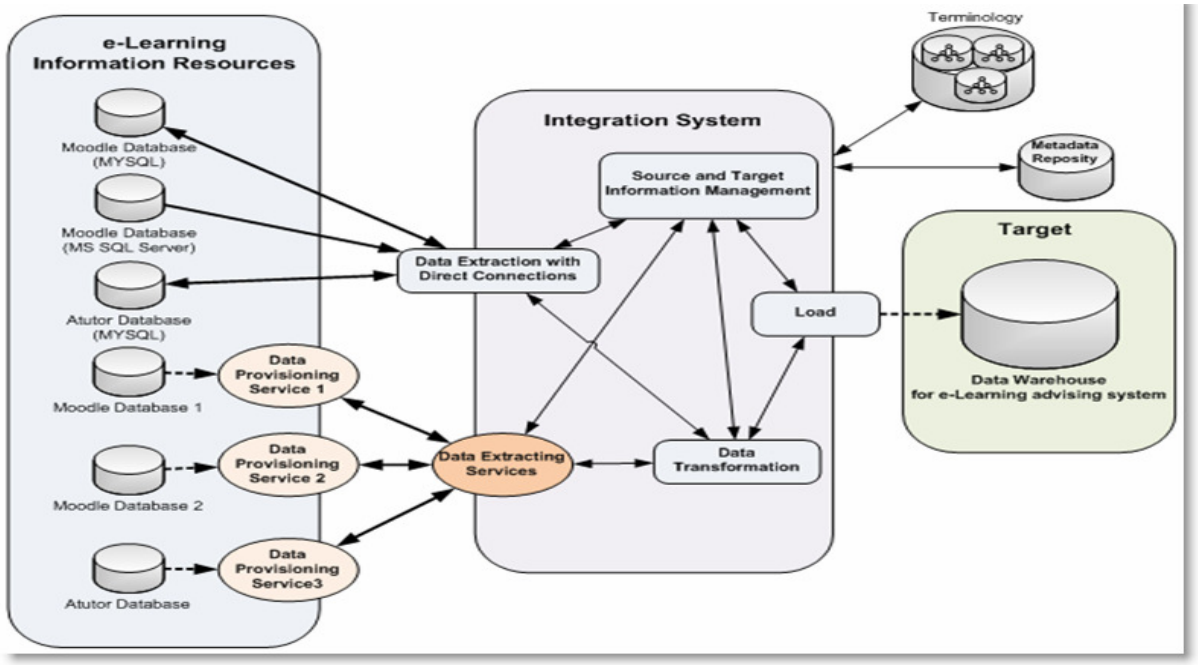



Fig. 3. Data Integration Tool Architecture supporting Academic Advising System.

## 5. Preliminary results – a data integration prototype based on Web service

Extracting data from heterogeneous data sources and transferring data into the data warehouse system is one of the most cost intensive tasks in setting up and operating a data warehouse [12]. Especially, in academic advising system, building the Data Integration tool, which enhances access to and provision of high quality learning history-related information, is a very challenging task because it can often involve many educational organizations with various platforms and databases. In this context, to evaluate the Data Integration tool model, we implemented a Data Integration prototype that manages and integrates semantic metadata. The bottom layer of the architecture consists of autonomous data sources that may be structured or semi-structured. The current prototype supports the

mapping of relational databases and XML documents. The design and implementation following proposed approach are presented in this section.

The implemented prototype may be used to connect different sources and target systems, enabling the flexible integration of data sources into target system (i.e. the data warehouse). The approach is based on the idea of establishing the communication between these data sources and target based on the use of Web Service technology [15] to describe and dynamically integrate participating data sources and the deployment within a specific database system.

In this paper, we focus on the integration of heterogeneous schemas of heterogeneous learning information systems. In this approach, we are going to use predefined XML tags as proposed by the Dublin Core, XML Standard. Therefore it will be possible to use tools based on the XML standard to create, generate, and maintain such XML descriptions easily.

Hereafter, the ETL process of data integration into the data warehouse is illustrated by details of our case study: how the mapping task has been performed, which methodology has been applied, followed by some typical screenshots of different mapping steps in implemented prototype.

### *5.1. Defining a new data provisioning source*

In this step, the administrator will create information of the new data provider, account information as well as the e-Learning platform which is currently adopted along with the database in use. If the data provisioning source is provided by means of web services, then this information will also be defined.

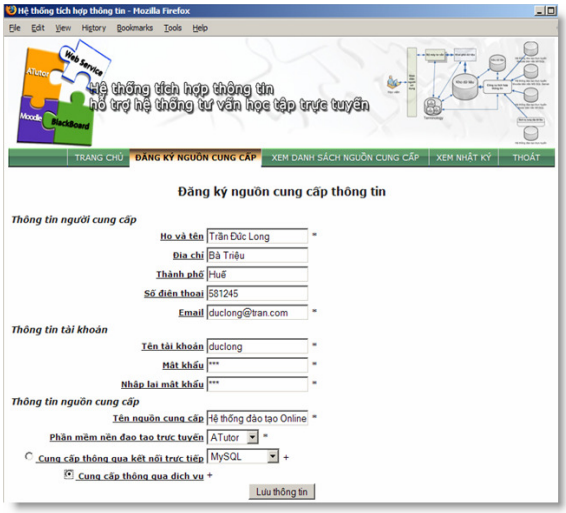



Fig. 4. Defining a new data provisioning source.

### *5.2. Identifying data provisioning service*

This step will define information about the data provisioning service used by sources. Based on this, system will connect to the service, thus obtain information about specific service activities, by means of the two lists of data provisioning functions.


Fig. 5. Identifying Data Provisioning Service.

The specified information will then be used to establish the connection to the data source in the next step.


Fig. 6. List of data provisioning sources.

### 5.3. Mapping

Based on the elements selected in above steps, a schema can be specified to represent the relationship among them, thus a mapping from this schema to the standard schema will be defined.

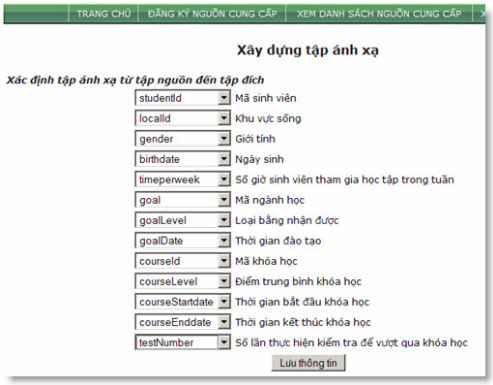



Fig. 7. Mapping from this schema to the standard schema.

### 5.4. Integration

In this step, the integration request will be delivered to the selected data provisioning source at a predefined time and the data will be harvested and converted to data warehouse standard, completing the data integration process (the ETL process).


Fig. 8. Data extraction from a data provisioning source.


Fig. 9. Transform and load data to the standard data warehouse.


Fig. 10. Log file of the ETL process.

## 6. Conclusion

In the context of emerging credit-based learning environment, it is our belief that to be a better help to learners, an academic advising system should implement in much greater measure at least the information giving, short-range program planning, student evaluation, and explanation of actions goals, as well as be capable of generating an optimized schedule [7]. Adding more flexibility in schedule adjustments, substitution of courses, and more sensitivity to student preferences and constraints would make it possible to cope with different categories of students [11].

Consequently, in this paper we have presented the design of a knowledge-based academic advising framework, adding intelligence to e-learning supporting tools, supporting the ability to understand and profit from learning history data. In the proposed framework, a learning data warehouse gathers and stores information coming from operation and navigational systems for future analysis by means of data mining techniques. A prototype of the presented Data Integration tool, one of

the most crucial components in the architecture, has been already implemented and tested at Hue University and results are very promising. Thus, the proposed approach creates a context in which learners can better understand the nature of the learning environment and more fully appreciate the importance of developing the skills, attitudes, and work habits that they will need to become truly independent citizens.

Our next steps include the extension of the system with semantic search capability and inference engine, as well as the adaptation of the conceptual framework presented here to establish well-known discovery processes real life academic advising system. Moreover, further research lies in the area of expanding the system with semantic attributes, such as adding semantic annotation to the Web services exported, in order to enable it with broader integration capabilities with other ontology based resources systems.

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